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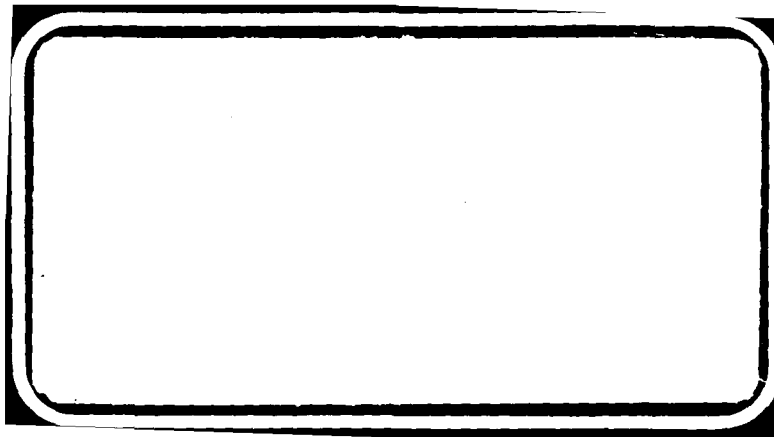
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ABSTRACT

Helicopter helmets in the Canadian Forces are required in two interchangeable roles, white and camouflaged. At present, helmets used by members of tactical helicopter squadrons are painted green to achieve the camouflage effect. Painting and stripping of helmets are time-consuming tasks which may deteriorate the impact protection of the helmet. Two adhesive coatings, olive drab gun tape and an adhesive vinyl coating in a disruptive pattern, were evaluated to determine the effect of extremes of temperature upon the coatings and the coated helmet shell. It was found that a marked discolouration of the helmet shell occurred during seven-hour exposures to 200° F when coated with olive drab gun tape. It is concluded that the adhesive vinyl coating is superior to the gun tape on the basis of appearance and discolouration of the helmet shells.

INTRODUCTION

DCIEM was tasked to evaluate the suitability of adhesive coatings as an alternative to paint for helmets worn by aircrew of tactical helicopter squadrons. The coating would be applied to the entire surface of the outer shell excluding the visor cover, which may be purchased olive drab; thus the coating will give a camouflaged appearance to the exterior of the helmet. It is expected that the application and removal of the coating will require less maintenance time and will cause significantly less degradation of the shell than painting the helmets.

The tasking specified that an adhesive vinyl coating of a disruptive pattern be trialed in comparison with olive drab gun tape. The evaluation was to be concerned primarily with degradation of the coating and the helmet due to exposure to extremes of temperature. Maintenance and user acceptance were also considered.

METHOD

As all the effects to be studied were related to the helmet shell, it was decided that only this portion of the helmet would be used. Thus, the helmet assembly tested consisted of the outer fibre glass shell the ensolite energy absorbing pads and the circumferential and suspension straps. The adhesive vinyl coating was a 3M product which consisted of a pigmented vinyl, backed with adhesive and silk-screened with a disruptive pattern. The gun tape used was a Dominion Tape Product. It is cloth tape with a pigmented vinyl covering and an adhesive back.

Three types of exposures were conducted: a cold exposure at -45°F for seven hours; a hot exposure at 200°F for seven hours; and a long term exposure at room temperature (uncontrolled) for twenty-one days. The seven hour duration for the exposures to extremes of temperatures was chosen to ensure that the coated helmets would reach thermal equilibrium. Both the adhesive vinyl coating and the gun tape were evaluated in each of these exposures. All coated helmets were stored for seven days at room temperature prior to environmental exposure. Later, it became apparent that the helmet shell discoloured after exposure to the high temperature when coated with either of the coatings. To investigate this, an uncoated helmet was hot soaked in the same conditions as the two coated helmets.

The oven used for the hot environment was a Style 287-A Dispatch Electric Oven Serial Number 41770. Temperature was monitored using a mercury thermometer in a stopper inserted through the oven wall. The cold exposure tests were carried out in a Cincinnati Freezer. The temperature was continuously monitored.

Both the cold and hot environment chambers were allowed to stabilize at the required temperatures. The coated helmets were examined to determine the physical condition of the coating and to record any degradation of coating appearance during the seven day lapse between the application of coatings and the start of the environmental exposure. The helmets were then placed in the chambers in a normal attitude, i.e. resting on the beading, such that the shells were not in contact.

The helmets were observed periodically throughout the soaking period to record any gross changes in the physical appearance of the coatings. These observations were made through a viewing port in the cold chamber and by opening the hot chamber door.

Both helmets were removed from a chamber and stripped of their coating simultaneously. One strip of the coating (either gun tape or the adhesive vinyl coating) was removed from the helmets immediately upon retrieval from the environmental exposure. Second and third strips of the coating were removed two and four minutes, respectively, after retrieval. The remainder of the coating was removed forty-eight hours after retrieval.

One helmet was prepared for the long term exposure. Due to a shortage of the adhesive vinyl coating, only two strips of this material remained, thus, each side of the helmet shell had two strips of one of the coatings applied longitudinally. After twenty-one days of storage at room temperature, protected from sunlight, the shell was stripped of its coatings.

In addition to the environmental tests, ease of application and removal of the two coatings was evaluated and the appearance of the coated shells was noted.

RESULTS and DISCUSSION

Application of Coating

a. Adhesive Vinyl Coating

This coating was supplied in 9" by 12" sheets. It was found during the process of applying the adhesive vinyl coating to the helmet, that it was difficult to conform to the shape of the outer shell using 3" strips without wrinkling the coating. Thus the material was applied in 1" and 2" strips. A 3" strip was applied along the centre line of the helmet running from the beading at the posterior edge of the helmet to the end of the strip 5" above the anterior edge. A 2" strip was applied on either side of this strip. Subsequently 1" wide strips were used to cover the helmet. At the end of this process, the frontal area of the helmet was uncovered. This area would, in a normal configuration, be concealed by the visor housing. In order to have the material conform to the helmet, it was necessary to stretch the material. This stretching occasionally caused fine cracks. These cracks were a result of the separation of the more brittle paint layers of the coating as the ductile tape was stretched.

Although some overlap was required to ensure an uninterrupted coating, it did not result in a serious build-up of the material. The coating was very thin and two or three layers did not affect the profile of the helmet.

The adhesive vinyl coating had to be applied by cutting the strips to the appropriate width, then the backing was split in the middle of each strip and peeled outwards as the coat was applied from the centre. The approximate time for application was one hour per helmet.

b. Gun Tape

This tape was found to be very pliable and conformed well to the helmet shape. For both helmets, the coating was applied in 2" strips off the roll. One helmet had the coating applied longitudinally starting at the centre line. The other laterally from the posterior edge of the helmet.

Overlapping the coating was deemed unacceptable due to the bulk of the tape. Thus the material was trimmed and mated edge to edge. The time for application was approximately 45 minutes per helmet.

Observations Prior to Environmental Testing (Seven Days After Application of Coatings)

a. Adhesive Vinyl Coating

It was noted that where strips of coating had been stretched during the application process, some shrinkage had occurred along the length of the strip. This exposed small areas of the helmet near the end of the strip. Some lateral shrinkage was noted where the coating strips had not been overlapped.

b. Gun Tape

The pigmented vinyl layer of the tape appeared to wrinkle away from the adhesive cloth where the tape had been stretched. At the edge, this wrinkling exposed the cloth backing in some locations.

Observations of Coating Appearance During Trials

a. Adhesive Vinyl Coating

No changes were noted in the external appearance of this coating under any of the test conditions.

b. Gun Tape

HOT: After 15 minutes of exposure at 200°F the Gun Tape had taken on a wrinkled appearance over approximately 15% of its surface area. This wrinkling occurred most noticeably around the edges of the helmet where there was no impact attenuating foam layer. As the soak progressed, so did the extent of the wrinkling. The pigmented vinyl began to shrink back from the edges leaving white strips of exposed cloth backing between the strips. In the sixth hour of the soak, the tape began to blister and some blisters had broken by the end of the trial, giving the coating a speckled

appearance. This blistering was limited to those areas of the helmet which did not have an ensolite backing.

COLD: No changes were noted.

Removal of Coatings Immediately on Retrieval from Environmental Test Area

a. Adhesive Vinyl Coating

HOT: The first strip of coating was removed immediately upon retrieval of the helmet from the hot environment. It was noted that this strip removed a 1/4" x 3/8" piece of helmet finish from the helmet surface. Only the outer layer of the helmet finish was removed. Subsequent strips of coating were removed quite easily. Very few traces of adhesive remained on the helmet. The only adhesive seen was at the end of the strips (Figure 1A).

COLD: Removal of the first strip of coating was attempted immediately upon retrieval from the cold environment. The coating was very brittle and cracked several times when this attempt was made. As the coating warmed, it was removed uneventfully.

b. Gun Tape

HOT: The vinyl and cloth layers of the first strip were successfully removed. In the process, however, more than 75% of the adhesive was left on the helmet shell. The nickel plating was removed from one of the suspension mounting screw heads. The second strip also left some adhesive behind when it was removed. The last strip came away from the helmet surface cleanly. There were scoring marks evident on the helmet surface which correspond with the edge of the strips of tape. These were caused by the scalpel blade during the process of masking the tape edge to edge. Two pairs of blisters occurred at the same location on each side of the helmet. Two of the blisters were broken to determine the nature of the inclusion. A dry brown flaky substance was found. The symmetry of the blisters suggested that an error had been made in the manufacturing process which had been filled. The blistered areas were x-rayed to determine if they had been drilled holes, however, this examination revealed only irregular areas. As this helmet had not been refinished, it is assumed that the inclusions occurred during the manufacture of the helmet. A visit to the manufacturer's plant did not uncover any operation where an error could have been made and no evidence of backfilling of helmet surface irregularities was found. It can only be assumed that the blisters formed as water or some other solvent evaporated out of this substance. Figure 2 shows the unbroken blisters and the scoring. Figure 3 shows the depth of damage at the blister sites.

COLD: The first strip of tape peeled easily but left small quantities of adhesive behind. Subsequent strips were easily removed (Figure 4).

Removal of Coatings 48 Hours After Retrieval From Environmental Test Area

The adhesive coating and the gun tape were removed uneventfully after 21 days of exposure to room temperature conditions. No discolouration of the shell was noted in either application (Figure 5).

In order to assess the effect of longer exposures, 408 Squadron was requested to strip a helmet which had the adhesive vinyl coating applied six weeks earlier. This helmet had previously been painted green, thus discolouration of the helmet shell could not be assessed.

Discolouration of Helmet Shells (Table 1)

Some degree of discolouration of the helmet shell occurred in all shells subjected to the hot environment. The helmet shell is constructed of laminated fiberglass cloth and an epoxy type resin. Most resins of this type suffer a chemical breakdown at temperatures between 120°F and 300°F (1). It is suspected that an evaporation of either the products of this breakdown or solvents retained in the resin may cause a change in the pigment used to colour the helmets.

There were two observations which support this hypothesis, both of which were most apparent in the hot soaked, gun tape covered helmet. First, blisters in the gun tape appeared along the periphery of this helmet. This area is not backed by the energy absorbing foam. This foam is also marketed as a thermal insulator, thus the rate of heat transfer to the shell and hence the rate of evaporation would be greater in the unprotected areas. It is suspected that the vapours released caused these blisters. Secondly, the areas which showed the greatest discolouration were those to which the adhesive did not adhere upon removal of the first strip of the gun tape. It is suspected that the rate of evaporation was greater in those areas where there was a slight gap between the tape and shell, as the pattern of the speckles was aligned along the length of the tape without relation to the orientation of the tape along the shell.

Discolouration of the helmet shell may be deemed unacceptable on the basis of the colour change alone, however, if it is indicative of a breakdown or drying of the resin, it may compromise the impact protection of the helmet. The adhesive vinyl coated helmet suffered no more discolouration than the uncoated helmet when hot soaked.

TABLE 1.

<u>DEGREE OF DISCOLOURATION OF HELMET SHELLS</u>			
<u>EXPOSURE</u>	<u>HELMET UNCOATED</u>	<u>ADHESIVE VINYL COATING</u>	<u>GUN TAPE</u>
7 Hours at 200°F	Slight Yellowing of Shell	Slight Yellowing of Shell	Marked Discolouration Colour of Brown Eggs
7 Hours at -45°F	Not Evaluated	No Discernible Discolouration	No Discernible Discolouration
21 Days at 70°F	No Discernible Discolouration	No Discernible Discolouration	No Discernible Discolouration

CONCLUSIONS

1. The adhesive vinyl coating is less susceptible to dimensional and physical change than gun tape.
2. The adhesive vinyl coating conformed more easily to the helmet shell. The greater application time required is due to the cutting and peeling process. The application times were 60 minutes for the adhesive vinyl coating and 40 minutes for the gun tape coating.
3. Overlap of the adhesive vinyl coating is acceptable while that of the gun tape is not. It is also likely that the surface of the helmet could become scored in the process of drimming the gun tape to prevent overlap.
4. Removal at room temperatures is equally easy for both coatings after all temperature exposures. Gun tape leaves adhesive on the helmet shell when removed either hot or cold. The adhesive vinyl coating is difficult to remove when cold due to its' brittleness. Removal of this coating by an airman who desired a helmet for conspicuity in cold weather survival situations would demand either the removal of gloves or the use of some tool (e.g. knife, keys, etc).
5. The blisters observed on the helmet shell which had been coated with gun tape and hot soaked were due to some inclusion in the helmet shell. They were not necessarily a product of the gun tape coating.
6. Gun tape covering of aircrew helmets would probably be less acceptable to the users on the basis of appearance.
7. Gun tape allows a greater discolouration of the helmet shell in exposures to hot environments.
8. The adhesive vinyl coating is the more suitable covering for aircrew helmets flown in the tactical helicopter role.

RECOMMENDATIONS

1. The adhesive vinyl coating is recommended for use as an alternative to paint for DH411 helmets worn by aircrew of tactical helicopter squadrons.
2. A fleet wide user trial of the adhesive vinyl coating is recommended.

REFERENCES

1. WEAST, Robert, C. (ed.) Handbook of Chemistry and Physics, 56th edition, pp C-597-7.

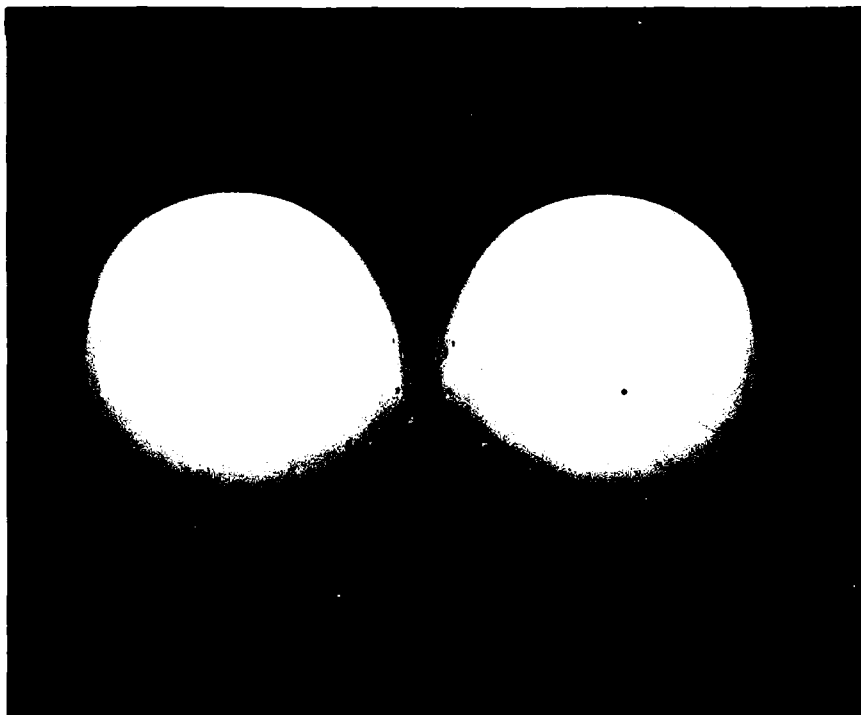


Fig. 1A Effect of seven hours exposure to 200°F.

The uncoated shell (left) showed slightly more discolouration than the adhesive vinyl coated shell (right). Small amounts of residual adhesive may be seen on the helmet at right.

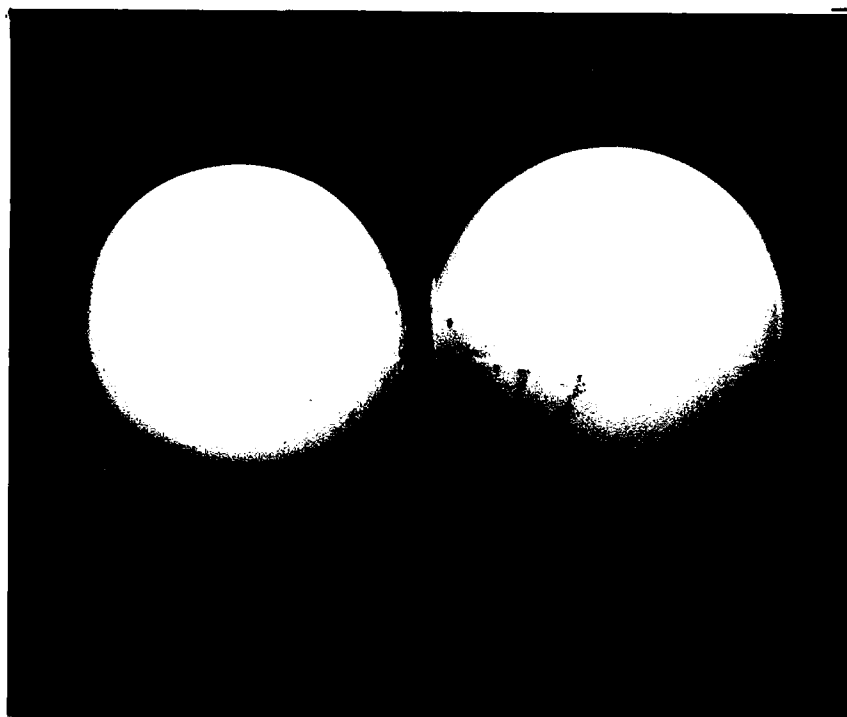


Fig. 1B The gun tape-coated shell (right) was more discoloured than the uncoated shell (left). Significant quantities of adhesive were left on the shell when the tape was removed immediately after the hot soak.

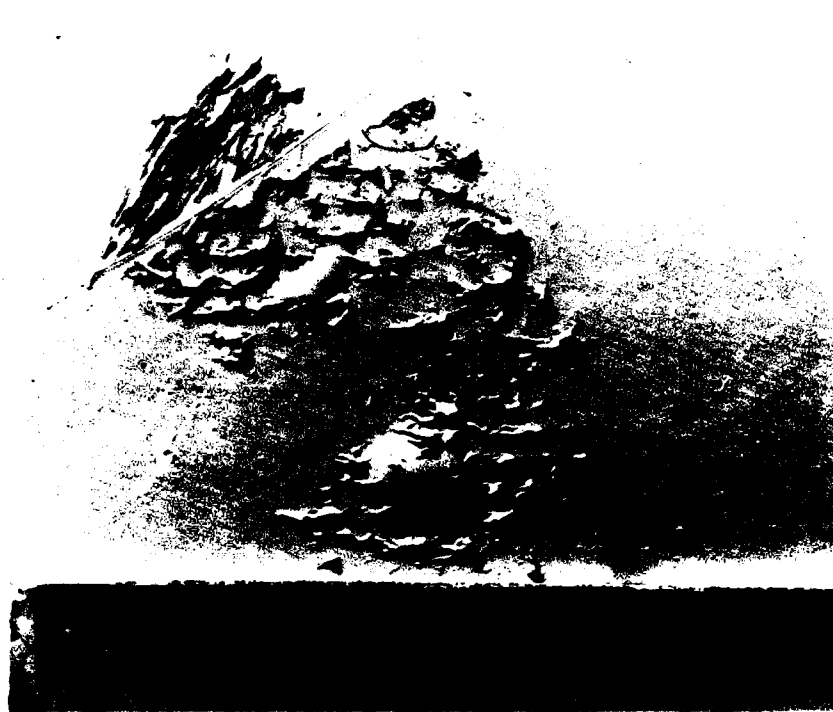


Fig. 2 The effect of gun tape upon a 411 helmet shell after exposure to 200°F for seven hours. Blistering of the outer shell is evident. Note the speckled appearance of the shell where there was no residual adhesive. It is suspected that the scoring occurred during the application process.



Fig. 3 The depth of the blisters found on a 411 helmet soaked at 200°F for seven hours. The blisters were broken to determine the nature of the inclusion. It is suspected that the blisters were due to an error in the manufacturing process.

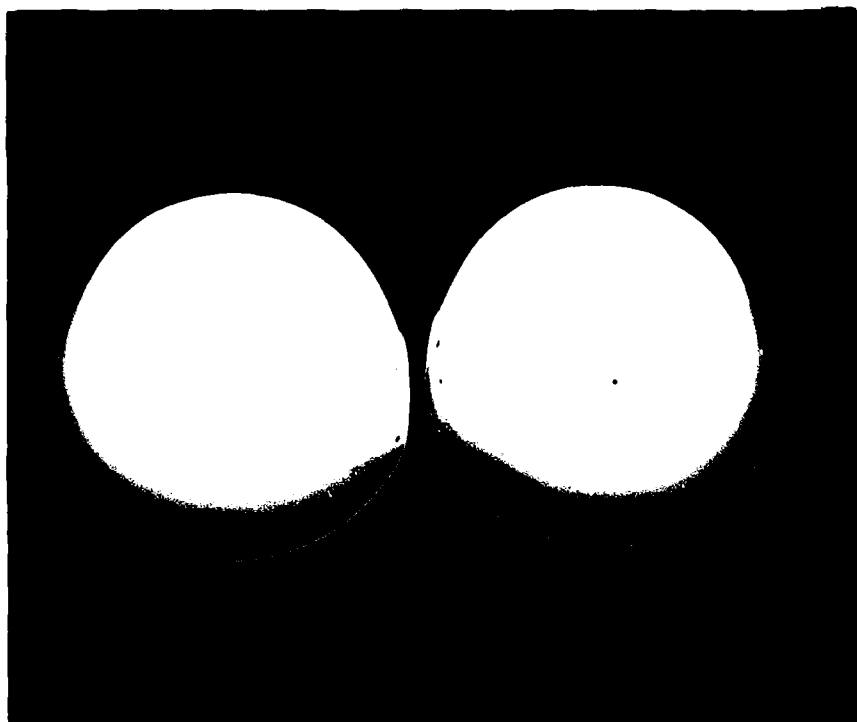


Fig. 4 Effect of seven hour exposure of coated helmet shell to -45°F . Neither the adhesive vinyl coated shell (left) or the gun tape coated shell (right) showed any discernible discolouration.

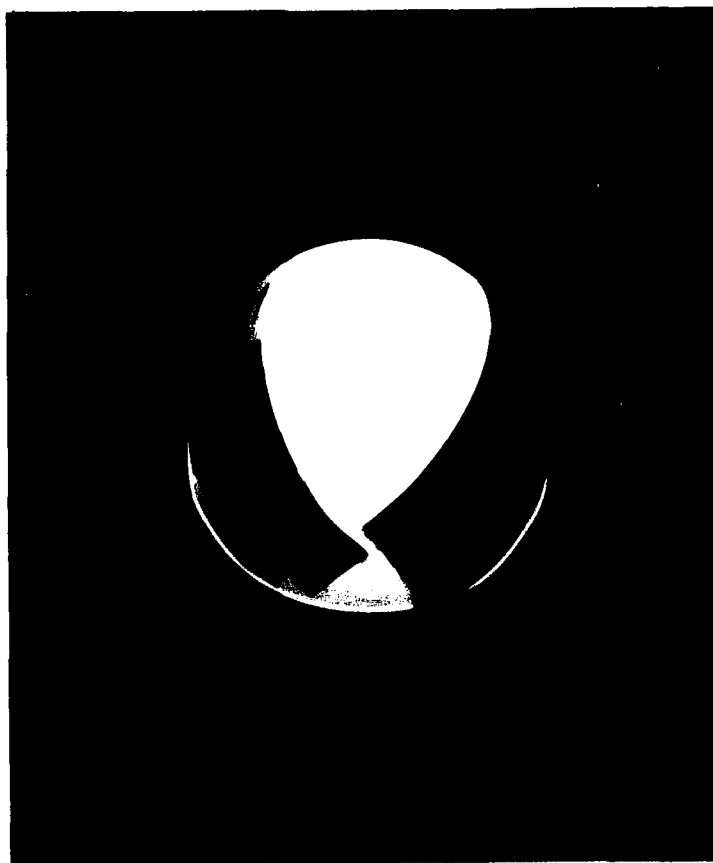


Fig. 5 Effect of 21 day exposure to room temperatures.

Fig. 5A Prepared shell before removal of both the adhesive vinyl coating and the gun tape.

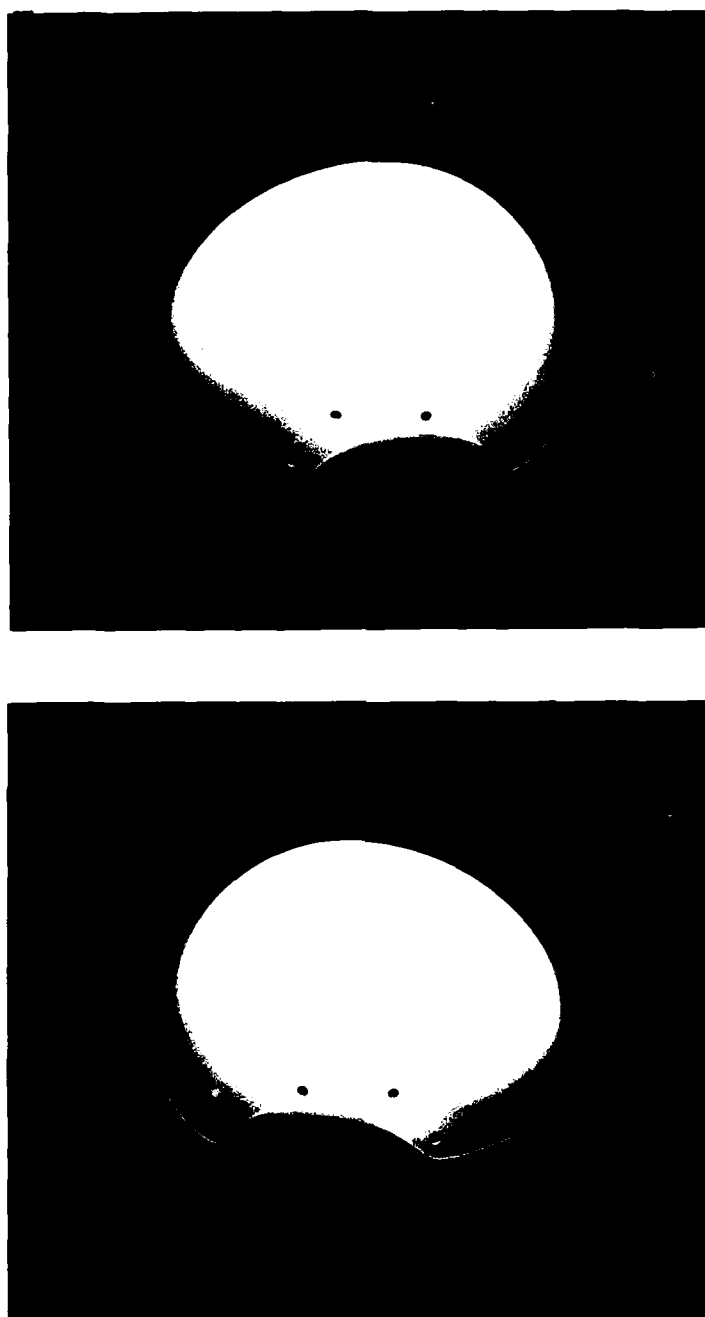


Fig. 5B Shell appearance after removal of coatings.
Note that there was no apparent discolouration or
residual adhesive for either the adhesive vinyl
coating (lower) or the gun tape (upper).